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ON *Brachionus dichotomus*, SHEPHARD, 1911 (ROTATORIA: BRACHIONIDAE) FROM THE AUSTRALIAN REGION, WITH A DESCRIPTION OF A NEW SUBSPECIES, *Brachionus dichotomus reductus*.

By Walter Koste* and Russell J. Shiel†

Abstract: *Brachionus dichotomus* Shephard, 1911, hitherto regarded in the literature as a doubtful species, is recorded from waters of eastern Australia. It is a valid species related to the *Brachionus caudatus* group. An intermediate, *Brachionus dichotomus reductus*, is described and figured. Ecological and distributional information is also given.

INTRODUCTION

Brachionus dichotomus was first described and figured by Shephard (1911:Pl. XXII, Figs 3, 4) from waters at Templestowe and Black Rock, Victoria. Only Harring (1913: p. 21) recognized the validity of the species. In the absence of further information, Ahlstrom (1940: p. 164), in his revision of the genera *Brachionus* and *Platyias*, included the species as a probable synonym of *B. falcatus* Zacharias, 1898, noting, however, 'If . . . Shephard's description is accurate, *Brachionus dichotomus* is a distinct species'. This uncertainty led to the exclusion of *B. dichotomus* from the list compiled by Gillard (1948: p. 210-211) of the known species of *Brachionus*. Voigt (1957: p. 157) mentioned the species with the imperfectly described forms of the genus, giving a figure (Tab. 72: Fig. 24). *B. dichotomus* was absent from Ruttner-Kolisko's (1972, 1974) comprehensive and definitive work on the planktonic Rotatoria, and Koste (1978: p. 83), on the basis of a literature search, found that the species was unheard of in the 66 years following its first description.

Surprisingly, in 1977, 1978 and 1979, populations of *B. dichotomus* were found in waters of Queensland, New South Wales and the Northern Territory by B. V. Timms, Avondale College, N.S.W. and R. J. Shiel, Dept. of Zoology, University of Adelaide. Examination of samples from the latter collector revealed that *dichotomus* indeed shows significant deviations from other species of the genus *Brachionus* Pallas with respect to morphology and especially to lorica spines (Figs. 1, 3, 5). A comprehensive account of rotifer morphology is given by Koste (1979).

In the communities of two biotopes were found forms with virtually similar lorica morphology, but with shorter spines. Comparison of the distinctive and characteristic markings of both taxa established that they were modifications of the same species. However the dissimilar size and form of the subitaneous eggs (Figs. 5a and 6a) and juveniles hatched from them (Figs. 5b and 6b) show a genetic separation of both populations. Several taxonomic features of the new form are intermediate between the type *B. dichotomus* and the *Brachionus caudatus* group, suggesting the affinity of *B. dichotomus* with the *B. caudatus* group, which belongs to the Formenkreis *angularis* (Figs. 8-9), and not, as previously incorrectly assumed, with the species group *falcatus* (Fig. 7), following Koste (1978: pp. 68, 81-84).

All figures were produced for comparative purposes in the course of the study. In addition data are given on the ecology and distribution of this probably endemic species and subspecies. Tables 1 & 2 give pertinent information on the present samples. The only other record of *B. dichotomus* after Shephard's initial records from Melbourne (37°49'S/144°58'E) is by Dr. B. V. Timms from farm dams at Gloucester, N.S.W. (32°01'S/151°58'E) (Sudzuki & Timms, in prep.).

MATERIALS AND METHODS

The available samples (#396, #572 and #589 from Shiel's collections) are subsamples, therefore an exact quantitative examination must be dispensed with. The dominance of warm, stenothermal rotifer species is, however, recognizable. Among these are

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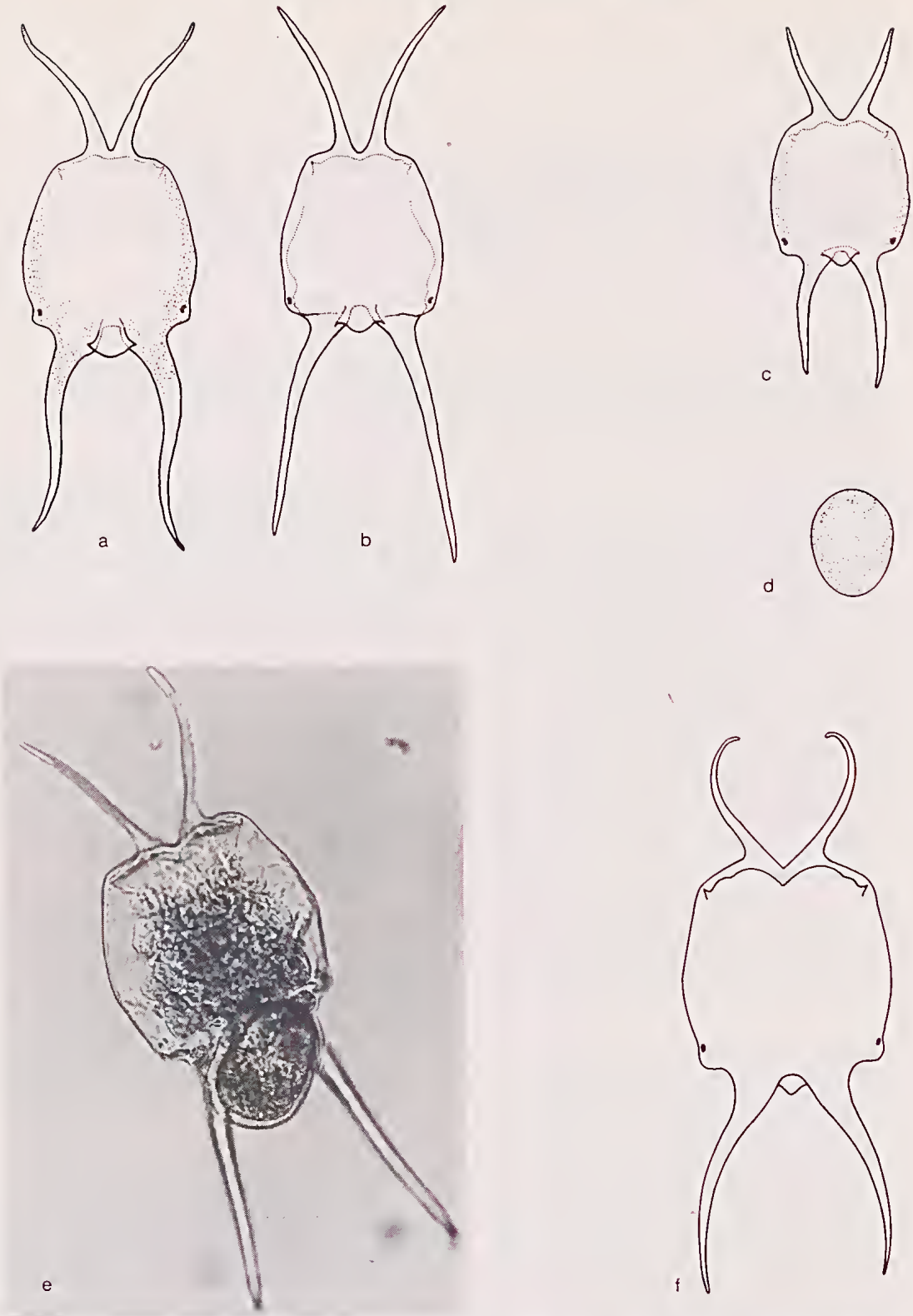


Fig. 1—*B. dichotomus dichotomus* a. Lorica ventral, 448 μm; b. Lorica dorsal; c. Lorica, juvenile, 304 μm; d. Subitaneous egg, 88/64 μm; e. amictic female with subitaneous egg; f. lorica ventral, 245 μm. a-e from Sawpit Lagoon, f. from Lake Mulwala.

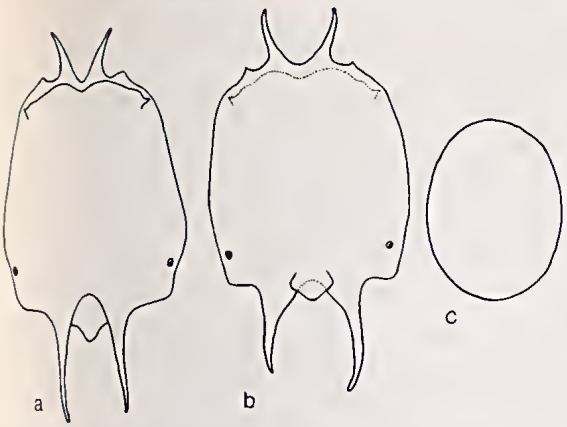


Fig. 2—*B. dichotomus reductus* Koste & Shiel, ssp. nov. a. lorica ventral, 148 μm; b. lorica dorsal; c. Subitaneous egg, 68/48 μm. a, b from sample 589.

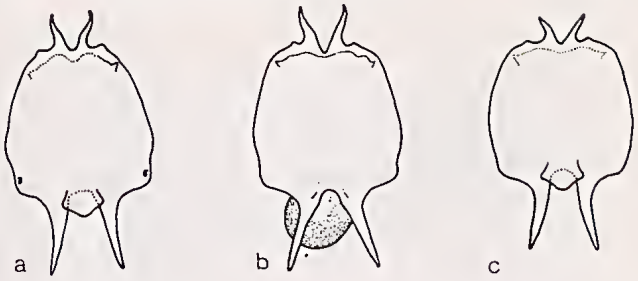


Fig. 4—*B. dichotomus reductus* a. lorica dorsal, 180 μm; b. lorica, ventral, with subitaneous egg (See Fig. 7a), 168 μm; c. lorica, dorsal.

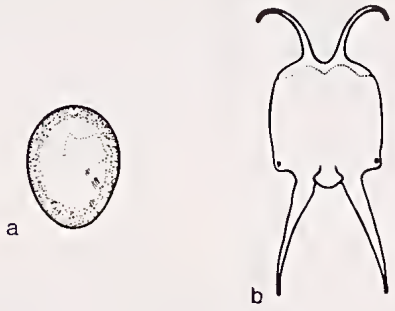


Fig. 5—a. *B. dichotomus* type, subitaneous egg, 80/60 μm; b. *B. dichotomus* juvenile 208 μm.

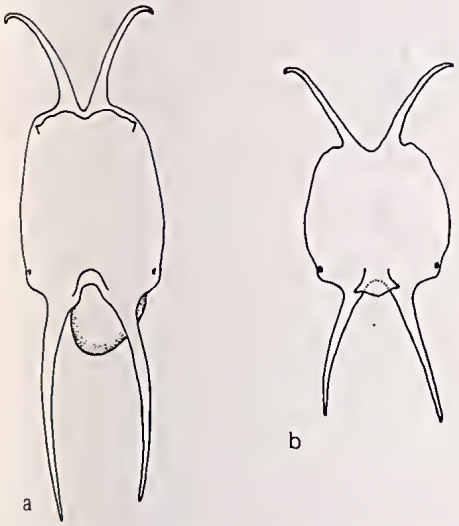


Fig. 3—a. *B. dichotomus* female with subitaneous egg, ventral, 372 μm; b. juvenile animal, dorsal. From sample 572.

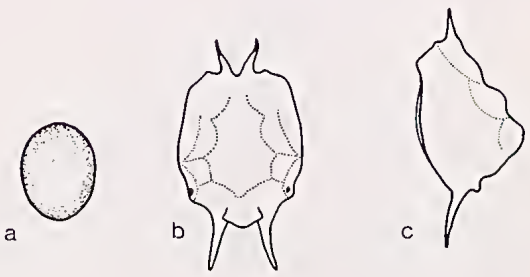
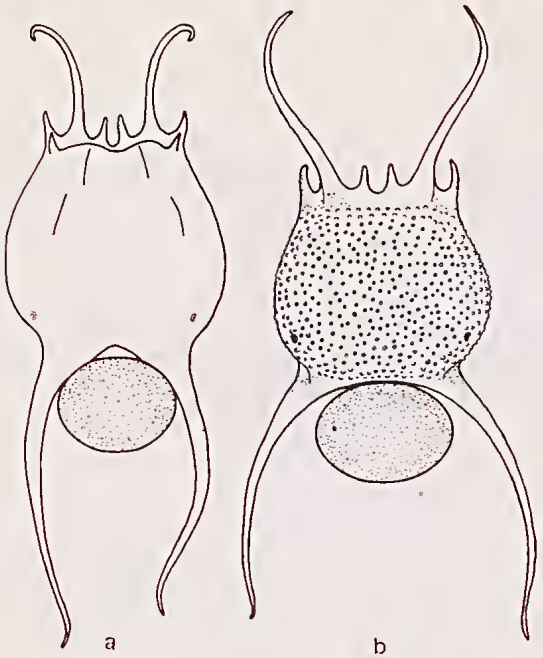


Fig. 6—a. *B. dichotomus reductus*, subitaneous egg, 64/44 μm; b. *B. dichotomus reductus*, dorsal lorica facetation; c. lorica, lateral.



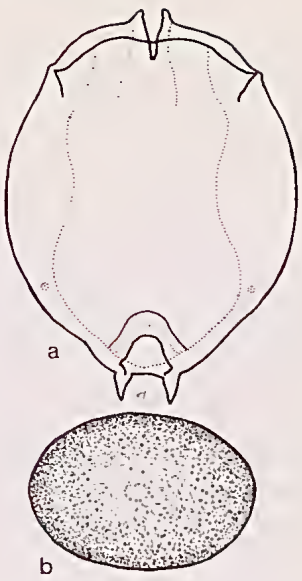


Fig. 8—*Brachionus angularis* f. *bidens* (Plate, 1886) from the River Murray. a. lorica ventral, total 135 μm; b. Subitaneous egg, 77/53 μm.

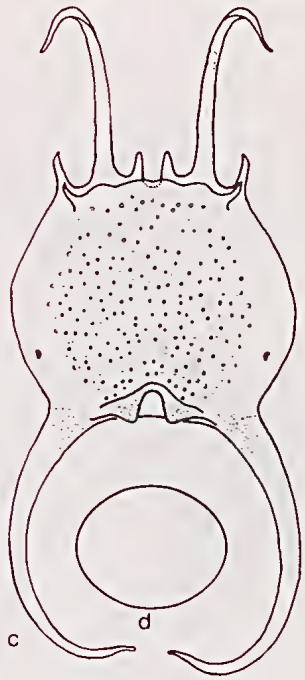


Fig. 7—*Brachionus falcatus*. a. ventral; b. dorsal; c. ventral; d. subitaneous egg. Samples from the Murray-Darling River system.

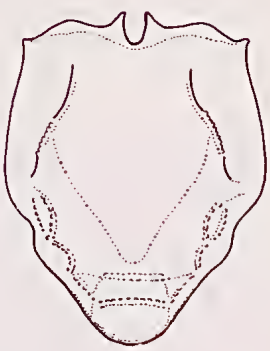


Fig. 9—An aberrant form of *Brachionus angularis* Gosse, 1851, from the River Murray system. Lorica dorsal, total 100 μm.

TABLE 1
PHYSICO-CHEMICAL PARAMETERS FOR THE HABITATS WHERE *B. dichotomus* IS RECORDED.

Locality	1 'Sawpit Lagoon', near St.George,Qld. Shallow open water.	2 Billabong of Mitta Mitta R. near Eskdale, Vic.Juncus.	3 Lake Mulawala, near Yarrawonga, Vic.Open water <1m.
Grid ref.	28°35'S/148°50'E	36°28'S/147°15'E	36°01'S/146°00'E
Collection date & number	23.05.78,#396	02.02.79,#572	04.02.79,#589
Water temp.°C	22.5	29.2	24.2
Dissolved oxygen ppm	8.4	8.0	8.2
pH	7.7	7.5	7.7
Conductivity µS	122	85	60
Turbidity NTU's	95	6	22

both cosmopolitan species, e.g. *Hexarthra mira,* and also pansubtropical and tropical species (*Brachionus falcatus, B. quadridentatus melheni, Filinia opoliensis, F. pejleri, Keratella lenzi, K. tropica, K. procurva, Sinantherina semibullata, Testudinella tridentata*). *Brachionus dichotomus* f. typ. and the new form are apparently endemic. The taxa of this species group occur sympatrically in two biotopes (samples 572 and 589) but only the f. typ. occurs in sample 396.

Species populations of the Group B. dichotomus in three samples:

Sample 396. From Table 2 it can be seen that *B. dichotomus* is the dominant form in this 'lagoon' (in fact a billabong of the Moonie River, Qld). Individuals are present with the long-spined lorica (Figs. 1, 3) distinctive of Shephard's described type (1911 Figs. 3, 4). In Fig. 1c is shown a lorica of 303 µm total length, including spines. Apparently this is from a juvenile (cf. Fig. 5b). The other adult loricate females have lorica lengths of 400-488 µm (Fig. 1a-b). The greatest lorica width in this population measures 148 µm. Shephard's measurements of 'length overall 0.3 mm, breadth 0.1 mm' are exceeded, indicating that this population has a larger lorica measurement (see Table 3). The dorsally curved anterior spines reach a length of 140 µm, the caudal spines 200 µm. Five females carried subitaneous eggs (88 µm long × 66 µm wide) on the dorsal lorica (Fig. 1e).

Sample 572: Two forms of *B. dichotomus* occur in this biotope, belonging to sympatric populations rather than to a polymorphic single population. The first form corresponds fully to the type. Juvenile individuals have lorica lengths of 200-288 µm (Fig. 1f). The adult lorica measures 380 µm (Fig. 3a). The subitaneous egg measurements (Fig. 5a) vary between 80-88/62-64 µm. The second form (Fig. 5) resembles *Brachionus caudatus* f. *vulgatus* Ahlstrom, 1940, so that initially it was not thoroughly examined (see Ahsltrom Plate VI, Figs. 6, 9, 10). On later detailed examination the affinity with *dichotomus* was established. See description of the new subspecies.

Sample 589. This sample, from Lake Mulwala, an impoundment of the Murray River below Lake Hume, contains a species-rich rotifer fauna in which pelagic and semi-pelagic forms are dominant, and *B. dichotomus* plays an insignificant role. The individual figured in Fig. 1f does not differ morphologically from the type, although the lorica length is small at 245 µm (cf. Figs. 1a & 1b). Figs. 2a-c show the external lorica appearance of a contracted fertile female *B. dichotomus* (second form) with subitaneous egg.

Brachionus dichotomus (second form):

The form of the lorica of this rotifer agrees fully with the type, shown by the deep insertion of the lateral antennae almost at the level of the top of the boundary of the ventral foot-opening, underlying which is the

TABLE 2
ROTIFERS FOUND IN THE THREE HABITATS OF TABLE 1

Habitats (Table 1)	1	2	3
Anuraeopsis navicula navicula Rousselet, 1910	—	22	8
Asplanchna priodonta priodonta Gosse, 1850	—	19	16
Asplanchna sieboldi (Leydwig, 1854)	4	18	—
Brachionus budapestiensis (Daday, 1851)	—	1	—
B. calyciflorus f. *anuraeformis* (Brehm, 1909)	7	8	1
B. calyciflorus calyciflorus Pallas, 1766	—	10	—
B. dichotomus dichotomus Shephard, 1911	14	16	2
B. dichotomus var *reductus* n. spp.	—	27	4
B. falcatus Zacharias, 1898	1	52	—
B. lyratus Shephard, 1911	—	26	—
B. quadridentatus melheni (Barrois & Daday, 1894)	—	6	—
Collotheca c.f. *mutabilis* (Hudson, 1885)	—	10	—
Collotheca c.f. *ornata ornata* (Ehrenberg, 1832)	—	1	—
Conochilus dossuarius dossuarius (Hudson, 1875)	5	—	12
Conochilus natans (Seligo, 1900)	—	—	2
Euchlanis meneta Myers, 1930	—	—	3
Filinia longiseta longiseta (Ehrenberg, 1834)	—	5	—
F. longiseta var. *limnetica* (Zacharias, 1893)	—	9	—
F. longiseta var. *passa* (O.F.M., 1786)	2	—	—
F. opoliensis opoliensis (Zacharias, 1898)	2	—	—
F. pejleri pejleri Hutchinson, 1964	—	—	8
Floscularia ringens ringens (Lamarck, 1758)	—	—	3
F. janus (Hudson, 1881)	—	—	2
Hexarthra mira mira (Hudson, 1871)	—	84	23
Keratella cochlearis (Gosse, 1851)	—	247	4
K. lenzi lenzi (Hauer, 1953	—	—	1
K. procurva (Thorpe, 1891	2	—	7
K. tropica (Apstein, 1907)	12	122	12
K. valga (Ehrenberg, 1834)	—	—	3
Lacinularia sp.	—	—	4
Lecane bulla (Gosse, 1886)	—	2	11
L. crepida Harring, 1914	—	—	1
L. (s.str) *hornemanni* (Ehrenberg, 1834)	—	1	—
L. luna luna (O.F.M., 1776)	—	—	4
L. lunaris crenata (Harring, 1913)	—	—	1
L. signifera signifera (Jennings, 1896)	1	—	—
L. signifera var. *ploenensis* (Voigt, 1902)	—	—	1
Macrochaetus subquadratus Perty, 1850	—	3	—
Polyarthra vulgaris Carlin, 1943	—	135	42
Sinantherina c.f. *semibullata*	–	–	2
Synchaeta stylata Wierzejski, 1893	—	—	64
Testudinella tridentata Smirnov, 1931	—	—	1
Trichocerca pusilla (Lauterborn, 1898)	—	—	6
T. similis similis (Wierzejski, 1893)	11	—	—

TABLE 3
COMPARATIVE MEASUREMENTS OF THE TWO FORMS OF *B. dichotomus*.

	B. dichotomus dichotomus	*B. dichotomus reductus*
Total lorica length (including spines)	200-488 μm	145-180 μm
Lorica length	84-140 μm	85-100 μm
Lorica width	80-148 μm	78- 90 μm
Length of anteromedian spines	55-140 μm	18- 28 μm
Length of caudal spines	80-200 μm	30- 45 μm
Subitaneous egg	80-88/60-64 μm	68/48 μm

swollen lateral formation of the lorica, and the dorsal, somewhat domed plate over the foot-opening (cf. Figs. 1a & 2b). This plate is described in Shephard's type description as follows: 'There is also at the posterior end, overhanging the bases of the spines, a projecting plate having a gentle outward curve in the centre, and a sweeping outwards at each side to form two short, acute points'. (c.f. Figs. 2b & 6b, c). Such a configuration of the dorsal boundary of the foot-opening is not known in *B. caudatus* forms (Ahlstrom 1940, Tables VI-VII). The lorica of the new form reaches a total length (including spines) of only 145-180 μm. The anteromedian spines are short (18-28 μm). Whereas anterolateral spines as found in the f.typ. are absent, rudimentary anterosubmedian spines are present. Fig. 3b indicates that such rudiments occasionally appear also in juveniles of *B. dichotomus* f.typ. The lorica of the new form is 60-64 μm high (Fig. 6c). The dorsal plate is occasionally faceted (Fig. 6b). The asymmetric posteromedian spines are conspicuously short (30-36/40-45 μm). The subitaneous egg measures 68/48 μm. Juvenile individuals (Fig. 6b) hatched from these reproductive bodies are distinctive in their appearance compared to f.typ. individuals of an essentially corresponding age group (cf. Figs. 5b & 6b).

The above-described morphological taxonomic characteristics of the lorica show a close affinity with *B. dichotomus dichotomus* Shephard 1911. However the dissimilar size of the subitaneous eggs and the form of the juvenile stage are indications of two genetically distinct populations. Also, the lack of modification of the type species raises the question of the taxonomic rank of this new *Brachionus* form. It is proposed, in the absence of geographic isolation, in a syntope (see Koste 1978: 51), to conclude that subspecific rank is appropriate. This rotifer is therefore named

Brachionus dichotomus reductus, ssp. nov.

HOLOTYPE: A permanent mount is lodged with the type collection of the Zoological Museum, University of Kiel, registration number Rot. 010.

DISCUSSION

Considerable variability (modifications) within the same population, with apparently undirected variations in the lorica spine shape and length, are not uncommon in the Family Brachionidae of the monogonontan Rotatoria (Genera: *Brachionus, Keratella, Platyias, Notholca, Anuraeopsis* and *Kellicottia*). They are observed synchronously and also at different times (seasonal polymorphism).

If populations of the same species from different ecologically distinct biotopes are examined, it is likely that they are seen as physiological races (var.) and are genetically fixed. This is illustrated by the variations in the *Brachionus falcatus* type, which the authors found in samples from different biotopes of the Murray-Darling River System (Figs. 7a-d). A comparison of this lorica form with that of the *B. dichotomus* species-group shows that any discussion on a closer relationship (Ahlstrom, 1940:164) of both species groups is unnecessary. The morphology of the *falcatus* group is comparatively constant. Only the structure of the lorica surface and the length and curvature of the anterior and posterior spines are variable.

The species-group *B. caudatus*, with its form series and taxonomic difficulties, is retained. *B. dichotomus reductus* tends towards an intermediate of this group. It has morphological conformity with *B. caudatus* f. *vulgatus* Ahlstrom, 1940 and also *B. caudatus caudatus* Barrois & Daday, 1894 (see Ahlstrom, 1940: T. VI, also Koste, 1978: T. 13, Fig. 8, 19-22). We note also that a *Brachionus* (Fig. 8) from Australian waters, with elongated foot-opening spines, can be seen to be an intermediate between the *angularis* and *caudatus* group. The taxa *B. angularis* (Figs. 8-9), *B. caudatus caudatus*, including f. *vulgatus*, as well as *B. dichotomus* (Fig. 1-6) are characterized by the absence, or only occasional occurrence or rudimentary structures (Figs. 2a-b, 4a-c) of the anterosubmedian spines. Anteromedian spines are always present. They are shortest in *B. angularis* (Figs. 8-9), longest in *B. dichotomus* (Figs. 1-6).

In the *caudatus* and *dichotomus* groups there is seen a caudally-inflexed elongation of the dorsal lorica. In *dichotomus*, however, this is terminated by a species-specific, bordered and domed tongue-shaped plate. Foot-opening spines (Fig. 8a) of variable length and form occur only in the *angularis* group. They are absent in the taxa *B. caudatus* and *B. dichotomus*.

Instead these possess narrowly-framed asymmetrical posterolateral spines of variable length.

Lorica and other measurements of the taxa are given in Table 3.

CONCLUSION

Particularly by reason of its anteromedian spines, the species group *dichotomus* is considered a unique member of the Formenkreis *angularis* ('*angularis*-group' after Ruttner-Kolisko, 1972:166; 1974:68; 'Formenkreis *angularis*' after Koste, 1978). Taxonomically it is assigned to affinity with the *caudatus* species-group. The greatest conformity with the type *B. caudatus caudatus* Barrois & Daday, 1894 is shown with respect to lorica shape and the number of anterior and posterior lorica spines. This semi-pelagic rotifer species, hitherto found only in E. Australia, is highly likely to be endemic to this zoogeographical region. After the new finds of Berzins (1963:*Keratella* (*quadrata*) *australis*, *K.* (*valga*) *slacki*), Sudzuki (1975: *Brachionus baylyi*) and Koste (1979: *Brachionus keikoa*, *Keratella shieli*), it is presumable that further investigation of the rotifer fauna of Notogaea (Australia and Tasmania) will produce additional endemic species.

ACKNOWLEDGMENTS

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